



Quality/Reliability Program

Our Philosophy

Product quality and reliability are two of the most critical elements for achieving success in today's semiconductor industry. Micrel has attained success as a semiconductor supplier by designing and processing parts that meet the most strenuous applications and most adverse environments. Micrel has accomplished this by never wavering from the philosophy that quality must be built into each and every device and process.

Micrel considers product reliability to be an expression of the quality philosophy extended over the expected life of each product. Micrel's philosophy begins in the design stage and continues, under strict monitoring and control, throughout the development, production, testing and packaging of each product.

Micrel's specific goal is to produce devices that are without defect from their given specifications for performance and product life. Product testing and comparative studies are ongoing activities at Micrel as we continue our search for new and more effective methods for manufacturing products with built-in quality. The Micrel quality program is in full compliance with MIL-I-45208, MIL-STD-883 paragraph 1.2.1 compliant non-JAN devices, and equipment calibration meets all requirements of MIL-STD-45662.

Quality Program Elements

Quality and reliability in Micrel products are obtained through a number of quality assurance program elements, most of which contain multiple levels of requirements and procedures. These program elements comprise the Micrel Quality Assurance Program.

I. Supplier requirements

Vendor certification of compliance to published specifications is required for process materials, gasses, substrates, masks, etc., as well as for components, parts and materials used in assembly.

II. Fabrication QA is based on a Statistical Process Control (SPC) Program including:

1. Test procedures
2. Document control
 - Specifications/recipes
 - Process change notice (PCN)
 - Engineering change notice (ECN)

3. Critical process-step monitoring
 - Particulates
 - Critical dimensions
 - Electrical performance
4. Extended SPC programs
 - Process Limit Control (PLC)
 - Process on Exception (POE)
5. Outgoing QA
 - Visual Inspection
 - To Micrel Standards
 - To Mil-883 Class B or Class S Requirements

III. Vendor Requirements

Certification of compliance to published Micrel or customer specifications is required for processes, materials, and services from third-party vendors.

IV. Assembly QA Program

1. Test procedures
2. Document control
 - Specifications
 - Control systems
 - Engineering change notices (ECN)
3. Critical-step monitoring
 - Assembly processes
 - Critical dimensions
 - Environmental processes
4. Acceptance Test Procedure
 - Electrical performance
 - Component marking
5. Outgoing QA
 - Visual Inspection
 - To Micrel Standards
 - To Mil-883 Class B or Class S Requirements

Organization

At Micrel, quality assurance management reports directly to the President of the corporation. All quality and reliability issues are independent of the production organizations.

The QA Manager's responsibilities are to establish and maintain effective controls for monitoring Micrel manufacturing and test services, equipment and processes (as well as our suppliers and contractors), to report the findings to the President, and to initiate statistically valid techniques to further improve Micrel quality and reliability levels.

The QA Manager is responsible for implementation and administration of multiple quality-related programs and systems for both commercial and military grade processes and products. Activities under the QA Manager's control include: incoming inspection, in-process quality control, qualification testing, conformance testing, document control, specification review, failure analysis, internal audit, quality procedures training, and ongoing vendor qualification and performance appraisal.

Statistical Process Control

Foremost of the Micrel quality assurance programs is their Statistical Process Control (SPC) methodology. Because of the company's unique mix of proprietary, custom and foundry products, SPC at Micrel is approached on two levels.

- Level 1 Traditional SPC utilizing process capability studies, design of experiments, Pareto analysis, histograms and X-bar R charting of critical process steps.
- Level 2 Extended SPC methodology adds Process Limit Control (PLC) and Process on Exception (POE) programs as sub-sets to the standard SPC programs.

Micrel's Process Limit Control (PLC) program provides absolute control of wafer runs during processing. Parameters are measured and recorded at every process steps against established limits. When any measurement value is found to exceed a specification limit, the run is immediately stopped and process engineering is notified. Before the run can proceed, engineering must evaluate the data and determine the run disposition during that production shift.

The Process on Exception (POE) program monitors and controls wafers during electrical testing. Wafer probe results are compared against specifications. Any exceptions to either absolute, preferred, or target specifications are noted and detailed reports are generated. Engineering may then exercise some influence over yield issues by determining which electrical performance criteria are critical.

The results of SPC, PLC and POE performance monitoring are reviewed on a monthly basis. Trends are charted, corrective actions are evaluated and process improvements are implemented as a result of the data.

Document Control

Document control is an integral part of the Micrel quality assurance program. It is designed to assure that operating procedures and customer requirements are translated into regulatory written instructions. Document control is responsible for initiating, approving, distributing, revising, recalling, and archiving internal control systems in the form of product run sheets (recipes), process and test specifications, etc.

Micrel's two main specification control methodologies utilize engineering change notice (ECN) and process change notice (PCN) systems.

- ECN The engineering change notice system follows standard industry procedures for process and test specifications, travelers, forms, and drawings.
- PCN The process change notice system is an extension of Micrel's unique, highly-detailed product run sheet (recipe) control system. PCN mechanisms meet the extreme demands for accuracy required in wafer processing.

Packaged product quality is controlled by a detailed set of instructions that are issued and controlled as part of the ECN system. These instructions cover all assembly and back-end processing steps and include the build-diagram, burn-in drawing, test set-up specification, test traveler, etc.

Inspection and Test Points

The flow charts accompanying this section describe the sequential steps of semiconductor processing and fabrication, and the associated test or inspection procedures and documentation.

Equipment Calibration

Micrel maintains a calibration system that conforms to MIL-STD-45662 and ensures measurement accuracy of equipment used to determine product workmanship and acceptability. Major provisions of the program include:

- Qualification of external calibration services,
- References traceable to National Institute of Standards and Technology (NIST). Identification of measurement and test equipment for type (electrical, mechanical, and optical) and frequency of calibration
- Certification history of equipment calibration and recall
- Recall status report history
- Audit history (calibration date stickers and recall designation)

Quality Control

The quality control program includes multiple inspections of material in-process, as well as final acceptance inspection of outgoing finished products. The QC system comprises product integrity characterizations of dimensional, structural, electrical and visual parameters. It also includes environmental and procedural monitoring checks.

The program elements include, but are not necessarily limited to:

- Particulate monitoring
- Temperature and relative humidity monitoring
- Electrostatic discharge monitoring and control
- Specification compliance reviews
- Random monitoring of wafers in-process
- Critical dimension qualification of product lot samples
- Wafer/die electrical sort
- Performance/trend data analysis
- Storage, handling, packaging and identification of raw materials, work-in-progress, and finished goods
- Returned material analysis

Finished product is inspected and tested prior to its shipment to the customer. Random sampling methodology is used to check deliverable wafer, die or part quality against published Micrel workmanship standards and customer specifications.

This final-product quality control program includes systems and procedures that assure the following:

- Correlation and qualification of test equipment to internal and customer specifications
- Manufacturing test operations are proper and complete
- Product lots conform to detailed test requirements for visual, mechanical and electrical performance criteria
- Documentation for each product/lot is proper and complete

New Products and Processes

New products or major process changes must undergo complete evaluation before they are certified at Micrel. Quality Assurance participation and approval is required in new product design reviews, product characterization and reliability studies, and documentation preparation.

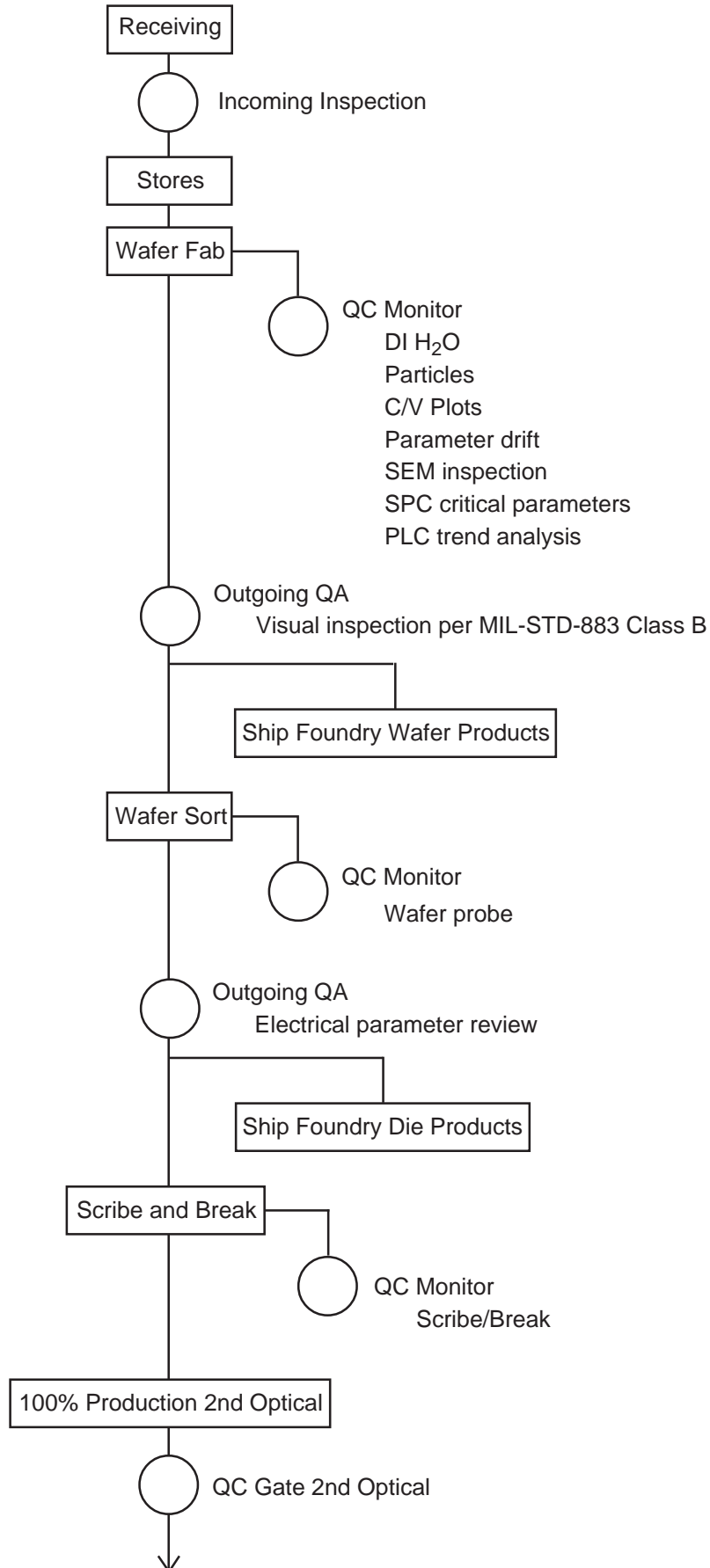
Certification is granted to new products or processes only after rigorous stress-testing, thorough monitoring of critical dimensions, careful failure analysis, and full process/trend data review. New packages are qualified and released for production only after Quality Assurance has determined that all environmental, mechanical and electrical tests are satisfactorily completed.

Complete and proper documentation of all material, process, procedure or packaging changes is required for final Quality Assurance certification.

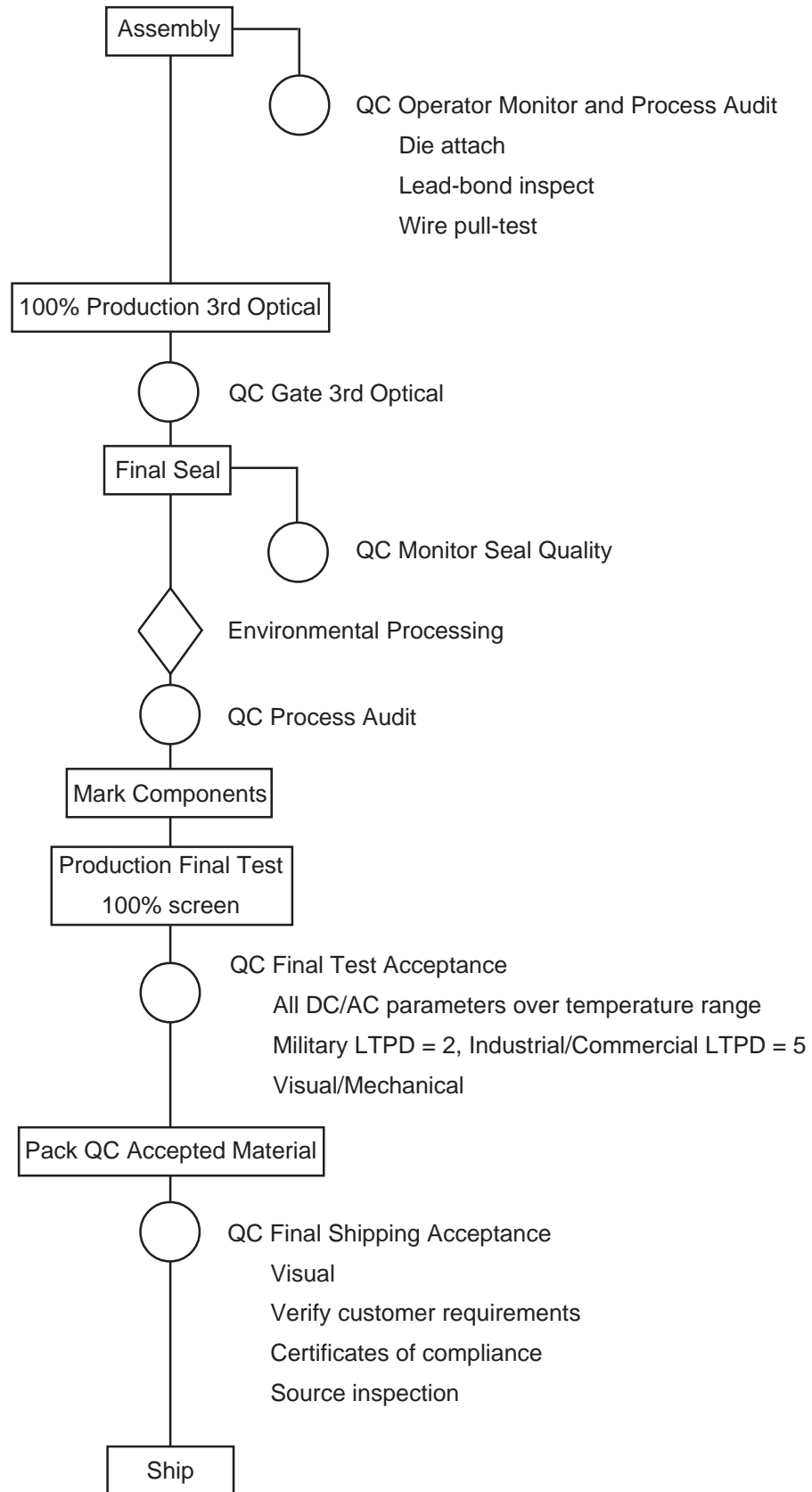
Summary

The Micrel Quality Assurance philosophy — that quality must be built into every process and product — is realized by the company's thorough implementation of the policies, procedures and processes required to ensure that our products and services meet the highest standards for material and workmanship.

Micrel Quality Flow for Semiconductor Circuit Manufacturing



Micrel Quality Flow for Semiconductor Assembly



Customer Returns

Perform analysis, answer and/or generate corrective action request, make disposition of return.

Specification Review

Review internal specifications, verify agreement to customer requirements, issue specification to production.

Reliability Assurance

Qualification — Test each device family in accordance with MIL-STD-883, Method 5004 and 5005, Class B requirements.

Certification — New products and major process changes subjected to accelerated test and process analysis.

Failure Analysis — Performed on all Qualification and Process Monitor failures and customer returns as needed.

Document Control — Maintains files of all latest drawings and specifications, controls and issues wafer run-sheets, specifications, drawings and ECN numbers, distributes copies to specification control books and user groups.